Modeling a Strainer

A strainer is a device installed in a piping system which provides a means for mechanically removing foreign particles from a flowing fluid. Most strained particles are in the size range between 40 micron and 1 inch, and are typically removed by using a perforated, mesh, or wedge wire straining element. For some processes, the particles are undesirable and the purpose of straining these particulates is to protect downstream mechanical equipment such as pumps, heat exchangers, control valves, flow meters and spray nozzles from the detrimental effects of flow debris. It also serves to prevent this debris from ending up in the final product in some manufacturing cases. Other processes may require straining because the particles, not the process fluids, are the desired product.

Types of Strainers

Two of the most common types of strainers are the “Y” strainer and the basket strainer.

Y-Type Strainer

The “Y” strainer has one fairly universal design and can be used in horizontal and vertical piping applications as well as high pressure applications.

Basket Strainer

There are many varieties of basket strainers, including simplex (one basket), duplex (two baskets, see Figure 1), and automatic self-cleaning strainers. All operate on the principle that the fluid flows through the straining element which captures the debris. Basket strainers are typically utilized for high flow processes.

Strainer Hydraulic Performance

A strainer is a mass transfer device with a pressure drop and flow rate relationship that can typically be represented with a second-order curve. The hydraulic performance data of a Eaton duplex strainer respective to strainer size can be reviewed in Figure 2. (Note that the linear relationship on a log-log scale represents a second order relationship on a linear scale). For incompressible flow, the pressure drop and flow rate is characterized by the following relationship:

\[ dP = \left( \frac{Q}{C_v} \right)^2 \]

The hydraulic performance can also be defined using a flow coefficient \( C_v \) for the corresponding strainer size. Table 1 shows the equivalent flow coefficient for the hydraulic performance of each of the Eaton duplex strainer sizes shown graphically in Figure 2.
Table 1. Duplex strainer flow coefficients based on strainer size (courtesy of Eaton).

<table>
<thead>
<tr>
<th>Size</th>
<th>Value</th>
<th>Size</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>9</td>
<td>2&quot;</td>
<td>42</td>
</tr>
<tr>
<td>1&quot;</td>
<td>13</td>
<td>2-1/2&quot;</td>
<td>65</td>
</tr>
<tr>
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<td>110</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>25</td>
<td>4&quot;</td>
<td>175</td>
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</tbody>
</table>

Modeling a Strainer in PIPE-FLO®

When a strainer is installed, the strainer’s components create obstructions in the flow path. These obstructions have a pressure drop associated with them. While PIPE-FLO® does not have a device specifically for strainers, their associated pressure drop and flow rate profile can be modeled using various methods. These methods are outlined below for a 3” Eaton Duplex Strainer. Comparisons of the calculated pressures, pressure drops, flow rates, and changes of a supply pump's total head requirement can be viewed in Figure 3.

Using a Fixed $C_v$

A Fixed $C_v$ fitting can be added to the Valves and Fittings of a pipeline to model the strainer. For the 3” Eaton strainer listed in Table 1, the flow coefficient value ($C_v$) is 110. Figure 4 shows the Valve and Fitting dialog and data entry. Note that the equivalent Resistance Coefficient (K) is calculated as 6.52 for the 3” pipeline it is installed in. For more on flow and resistance coefficients please [click here](#).

Using a Curved dP Device

Figure 3. 3” Strainer modeled in PIPE-FLO® Professional. Compares calculated results using a Fixed $C_v$ and Curved dP device.

Figure 4. A clean strainer modeled as a Fixed $C_v$ fitting in a pipeline.
A Curved dP device can also model the strainer by using the data provided by the manufacturer's hydraulic performance graph in Figure 2. Data points taken over a range of flow rates on the graph can be entered in a Flow vs. Pressure Drop table. The accuracy of the results is dependent on how carefully these points are read off the performance graph.

Figure 5. A clean strainer modeled as a Curve dP device with data points from the manufacturer performance curve.

Estimate Curve Data

Alternatively, just one pressure drop and flow rate point from the graph (or if the manufacturer graph is not available but a single data point is provided or can be measured) the "Estimate Curve Data..." feature of the Curve dP device can be used. By entering the single flow rate, dP, and a maximum flow rate, PIPE-FLO® will generate a data set that is a second-order curve from zero, through that point, and out to the maximum. This method is also shown in Figure 6.

Figure 6. A clean strainer modeled as a Curve dP device using an estimated second-order curve.

From Figure 3, it can be seen that for a flow rate of 206.3 gpm, the estimated curve is used to calculate a 3.496 psi pressure drop across the strainer. Reading off the manufacturer's performance curve (Figure 2), for 206 gpm through a 3" strainer, the pressure drop is approximately 3.5 psi. The estimated curve results are close enough to the actual curve to be within an acceptable degree of engineering certainty.

In the absence of manufacturer performance data or field measurements, a reasonable engineering approximation of pressure drop at the desired flow rate can be used to generate the second-order performance curve.

Dirty Strainer Performance

In operation, as the strainer removes particles from the process fluid, it can begin to partially plug. This affects the hydraulic performance due to additional obstructions in the flow path, increasing the pressure drop across the strainer at a given flow rate. This results in a steeper second-order performance curve as the flow coefficient decreases.

When modeling an existing system, a dirty strainer can cause discrepancies between field data and PIPE-FLO calculations, considering manufacturer data is typically for a clean strainer. Using the Lineup feature in PIPE-FLO, the performance of the dirty strainer can be modeled by taking the measured flow rate and pressure drop across the strainer and creating a new performance curve using the Estimate Curve Data feature. This will allow you to evaluate the effect of strainer plugging on the overall system. As seen in Figure 3, a dirty strainer increases the total head requirement of the pump, increases the strainer pressure drop, and decreases the flow rate of the process fluid, due to the additional resistances.

It's important to clean or replace the strainer element when the pressure drop exceeds a maximum pressure drop specified by the manufacturer (typically 5 to 20 psid).
Evaluation of PIPE-FLO Calculations

Evaluating the PIPE-FLO results shown in Figure 3, all of the methods to model a strainer provide reasonably accurate results and are comparable within reasonable engineering accuracy. PIPE-FLO allows you to model the hydraulic performance of a strainer and evaluate the effect of plugging on the overall system operation.